AD NUMBER
AD510290
CLASSIFICATION CHANGES
TO: unclassified
FROM: confidential
LIMITATION CHANGES
TO: Approved for public release, distribution unlimited
FROM: Distribution authorized to U.S. Gov't. agencies only; Critical Technology; FEB 1966. Other requests shall be referred to Office of Naval Research, ATTN: Code 458, One Liberty Center, Suite 1425, 875 North Randolph Street, Arlington, VA 22203-1995.
AUTHORITY
ONR ltr dtd 29 Apr 1974; ONR ltr dtd 29 Apr 1974

SECURITY MARKING

The classified or limited status of this report applies to each page, unless otherwise marked.
Separate page printouts MUST be marked accordingly.

THIS DOCUMENT CONTAINS INFORMATION AFFECTING THE NATIONAL DEFENSE OF THE UNITED STATES WITHIN THE MEANING OF THE ESPIONAGE LAWS, TITLE 18, U.S.C., SECTIONS 793 AND 794. THE TRANSMISSION OR THE REVELATION OF ITS CONTENTS IN ANY MANNER TO AN UNAUTHORIZED PERSON IS PROHIBITED BY LAW.

NOTICE: When government or other drawings, specifications or other data are used for any purpose other than in connection with a definitely related government procurement operation, the U. S. Government thereby incurs no responsibility, nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use or sell any patented invention that may in any way be related thereto.

HUMAN FACTOR PROBLEMS IN ANTI-SUBMARINE WARFARE

TECHNICAL MEMORANDUM 206-36

A REVIEW OF SOME HUMAN FACTOR CONSIDERATIONS IN THE BQR-7 DIMUS (DIGITAL PRE-FORMED BEAM) DEVELOPMENT (U)

HUMAN FACTORS RESEARCH, INCORPORATED
SANTA BARBARA • LOS ANGELES • SAN DIEGO

Report on HUMAN FACTOR PROBLEMS IN ANTI-SUBMARINE WARFARE.

Technical Memorandum 206-36

A REVIEW OF SOME HUMAN FACTOR CONSIDERATIONS IN THE BQR-7 DIMUS (DIGITAL PRE-FORMED BEAM) DEVELOPMENT (U)

Walter R. Harper

...is document
...der only

In addition to ...
and must be ...
with spe...

ONR/Arch 458
Arlington, Va 22217

by

Human Factors Research, Incorporated
3040 State Street
Santa Barbara, California 93105

February 1966

56p.

Contract Nonr-2649(00)
NR-153-199

172 pp

This research was sponsored by the Office of
Naval Research under Contract Nonr 2649(00),
ONR Authority Identification NR 153-199.

ABSTRACT

Selected aspects of the BQR-7 DIMUS development were reviewed which involve the interaction between the sonarman and the proposed DIMUS equipment.

Three volumes produced by the DIMUS contractor were reviewed with the objective of comparing DIMUS with the existing BQR-7 system including details of equipment design, displays, controls, and maintenance philosophies. The theoretical contribution that the DIMUS would make to the performance of the BQQ-2 system was examined.

The review presents specific points in detail for the technical reader and a general summary for those with limited knowledge of the DIMUS system.

The comments included herein illustrate a divergence between experimental/laboratory work and the operational world in which this sub-system will operate as part of the BQQ-2 sonar system.

Table of Contents

REVIEW OF VOLUMES I/II AND FINAL REPORT OF THE AN/BQR-7 (DIGITAL MULTIBEAM STEERING) DIMUS STUDY (U)

I. INTRODUCTION

THE TASK

The BQQ-2 Project Office, A.S.W.S.P.O., requested that Human Factors Research, Inc., review those aspects of the BQR-7 DIMUS development which affect, or are affected by, the sonar technician's interaction with the proposed equipment.

SCOPE

The assigned task consisted of a critical review of three documents* produced by the equipment contractor. These documents were examined from several viewpoints. A brief comparison was made with the BQR-7 sonar system as presently installed. Comments are contained herein on details of displays and controls, maintenance philosophies, training, and the general contribution which the addition of DIMUS presumably makes to the BQQ-2 system.

Although most of the sub-systems of the BQQ-2 ar semi-automatic to some degree, the requirement for the human monitor, considered as operator, maintainer or data evaluator, appears to be just as critical to the BQR-7 DIMUS sub-system as it is in any of the older sub-systems.

---

* a) Volumes I and II Final Report, AN/BQR-7 All-Digital Preformed Beam Receiver Study (U). Dated 30 September 1965, Contract NObsr 91093, Items 1-2, Project Serial Number SF 001-03-06, Task 8239, General Electric Company, Heavy Military Electronics Department, Syracuse, New York; and

b) Program Plan for Phase II AN/BQR-7 DIMUS. Proposal 371-006, September 1965, Heavy Military Electronics Department, Syracuse, New York.

REVIEW FORMAT

This review is simultaneously addressed to two kinds of readers; those who are familiar with DIMUS signal processing techniques, and those who only have general knowledge of the purpose of DIMUS. To assist the reader, the subject matter has been arbitrarily divided into five general areas. It will be clear, however, from even a cursory examination of the material under review, that none of these categories is as clear-cut as its title would suggest. The categories are:

1. Equipment operation
2. Displays
3. Reliability and testing
4. Maintenance and repair
5. General

Each area is introduced with a short summary. This summary is followed by precise references to particular points in one of the three volumes under review. For the reader who is not concerned with the details, the summary should suffice since it highlights the observations made. For those interested in the specifics, the detailed material will be of additional value.

The detailed references to points of importance in the three volumes are appended to the end of this report for cross-reference purposes. These appendices are keyed to each volume of the text in the same numerical order as the text is read.

It should be to the advantage of the technical reader to have the referenced volumes close at hand so the various discussion points will not be read out of context.

The comments and discussion should not be construed as criticism. Rather, they are presented as examples of areas which are not explained clearly, or in some cases to illustrate a divergence between experimental or laboratory work and the operational world of the nuclear submarine.

DIMUS--THE EQUIPMENT AND ITS PURPOSE

DIMUS (Digital Multibeam Steering) is a signal processing and display technique intended to improve the detection capability of the BQR-7 passive sonar component of the BQQ-2 sonar system.

The AN/BQR-7 sonar is a long-range passive equipment presently installed on 594-class nuclear submarines.

Target signals are recorded continuously on a bearing-time-recorder display. A steered-beam audio display is also available for tracking one target at a time. The bearing of a particular target can be read from a dial on the operator's console and the data can be transmitted automatically to the fire control system.

The hydrophones for the BQR-7 sonar are mounted in vertical staves, in groups of three, in a horseshoe configuration conforming to the shape of the submarine's bow. There are 156 hydrophones organized into 52 staves. Each stave has its individual amplifier for boosting the received signal.

There are two independent compensator switches in the system. One compensator switch feeds the BTR from the output of a continuously scanning beam rotated at a preset rate. The other switch, which is manually positioned, controls a narrow beam which presents the audio signal to the operator.

One compensator can automatically sweep and record target signals on the BTR while the other is used for manual search detection and tracking. The audio beam is trained in azimuth by a "steering wheel" control mounted on the console.

The effectiveness of the BQR-7 passive sonar is reduced by own-ship noise during high-speed cruising. This apparently becomes critical over 5-6 knots. The question, then, is whether the

addition of the DIMUS modification is really justified in view of the marginal conditions relating to speed which reduce the capabilities of the BQR-7.

The DIMUS modification has been designed to correct some operational limitations of the BQR-7 system. At present, when the rotating compensator is scanning, the receiving beam only samples the output of some of the hydrophones. Of necessity, then, a great number of the 156 hydrophones are not producing useful data at any given instant in time.

With the DIMUS multibeam system it is proposed that continuous monitoring of all bearings can be achieved. The inputs from all hydrophones are sampled and averaged once every 124 microseconds. Sixty-two beams are formed and each is sampled every 2 microseconds. Delay lines produce a predetermined directional alignment of each beam, e.g., each beam output is the sum of each hydrophone input delayed by a fixed amount.

The information displayed to the operator consists of an audio signal as in the older BQR-7 system, but after processing, the incoming signals are also presented on a CRT display having some of the same characteristics as the bearing-time-recorder. This display has a memory system which enables target bearing information to be accumulated for periods up to one hour.

The basic rationale underlying the development of the DIMUS system is that an improvement in signal-to-noise ratio will be obtained. Detection range presumably will be improved although no data are as yet available to support this expectation. Much of the background and assumptions are derived from the results of tests carried out on the BQR-2B DIMUS and reported in 1961 (1). The implication is that an improved detection threshold was reported from the BQR-2B study; the same improvement will result from a BQR-7 DIMUS modification. But until rigid methods of

measurement are adopted common to all systems we cannct be certain that an improvement will, in fact, be shown.

Apart from the detailed questions raised in subsequent paragraphs of this review, serious philosophical doubts remain in the reviewer's mind on the ultimate benefits of the DIMUS plan. The addition of DIMUS to the already overly complex BQQ-2 system must, in our view, be balanced against realistic gains in performance, reliability and maintainability if the total system capability is to be increased.

In simplest terms we respectfully ask "How does the installation of DIMUS <u>really</u> improve the BQQ-2 system?" We would hope that the equipment contractor would provide some yardstick of expected performance improvement. The answer is not contained in the volumes under review.

II. REVIEW

1. EQUIPMENT OPERATION

Noise on the bright-tube display is expected to appear as bright spokes. It is reportedly desirable to repress these spokes to obtain maximum detection capability. There are two modes provided to repress spokes, manual and automatic. The equipment may also be operated without spoke repression. Assumptions concerning when each mode should be used are made in the manufacturer's documents without supporting data. There are also assumptions about how certain operating controls should be set, and how the equipment should be operated in general.

In connection with the manual spoke repression mode, reference is made to the operator function of inserting integer numbers, quantized in steps of eight, into the memory. How this is done or the consequences of errors in making this insertion is not explained.

Similarly, when using automatic mode, reference is made to a "latest available value" without clarification of what this value is or where it comes from.

The operator is described as "not overloaded with work" and by inference is to be capable of discriminating between signal and noise. This capability is to be gained by experience. Our observation, based on a number of past studies, is that optimum operating technique rarely develops solely on the basis of "experience" but rather requires more formal training procedures.

The display is to have a memory function which will permit data up to 1/2 to 1 hour old to be recalled for display. This time is not to be under operator control. The exact amount of memory time available is unresolved and will depend on the resolution of data-handling rates and numerous timing problems.

Perhaps some of the potential problems raised in the preceding paragraphs could be resolved through discussions with the manufacturer. However, without some clarification, it would seem unwise to accept the statements made as resolutions of these problems.

The precise references to the location of the quotations in the texts are given below. Each reference is cited and a comment made.

Vol. I Page ref. II-57

Re: Operator/Workload. "The operator is not overloaded with work but is now left with the capability of eliminating target traces along with the interference. Experience will be required to learn under what circumstances it is desirable to select a new repressor output."

Comment: (a) The validity of this assertion concerning the operator's (task) workload and his

capability of eliminating target traces is not obvious.

(b) How is this experience gained? Does it refer to operator experience solely obtained at sea using live targets and extracting operational information? Or does the statement refer to familiarity with the equipment such as would be gained at a school?

Vol. I Page ref. II-56

Re: Displays/Operation. "The operator must determine by clues, such as zero relative bearing rate, that these are not targets and adjust out these differences."

Comment: (a) Other clues are not listed. Can they be anticipated? Are all signals with zero relative bearing rates to be considered as noise?

Vol. I Page ref. II-56

Re: Displays/Operation. "If variables change rather frequently, e.g., hourly, the operator must exert much effort in keeping the spoke repressor adjusted."

Comment: (a) What is meant by "much effort"?

Vol. I Page ref. II-58

Re: Display Time. (1) "Time averager outputs up to half to one hour old must be recalled for display." (2) "A purely subjective feeling that at least a half-hour history (preferably up to one hour) should be displayed."

Comment: (a) It is never expressly stated exactly why this time period was selected beyond providing additional history to help and maintain contact on questionable targets. Probably some relationship to information requirements should be established.

Proposal Page ref. II-15

Re: Long Time Averager. "...cycle length is selectable by the operator."

Comment: (a) What are to be the operator's criteria governing selection?

(b) What are the results if the wrong selection is made?

Proposal Page ref. II-17

Re: Manual Mode. "Integer numbers in the range ± 1023, quantized in steps of eight, shall be capable of being inserted by the operator, one beam at a time."

Comment: (a) There are 62 beams. How does the operator insert the relative integer numbers into the memory?

(b) What are the variables which govern insertion?

Proposal Page ref. II-17

Re: Automatic Mode. "An operator control shall allow replacement of the value being used for spoke repression by the 'latest available value.'"

Comment: (a) What is the "latest available" value?

(b) How is such a value made known to the operator?

(c) What happens if the value in use is not replaced by the latest available value?

2. DISPLAY CHARACTERISTICS

Signals from the DIMUS processing will be presented to the operator on a bearing vs. time CRT display which will replace the

present BQR-7 graphic bearing/time recorder. The cathode-ray tube will be a raster-scanned type of at least 300 lines capacity. Each line will consist of 90 intensity modulated marks. The display will be backed by memory so that information up to one hour old may be presented on demand although the display screen is capable of only 30 minutes. Each line of raster will display information received and processed at regular intervals, proceeding chronologically from top to bottom. For example, line number 1 will present the latest information, line number 2 will display information from the immediately previous period, line number 3 will display information from two periods back. This process will be continued for all display lines so that a historical record is provided. Targets are presumably detected by searching for line segments with above-average marking density.

The display will include a manually positioned, electronic cursor in the form of a vertical line. A horizontal bearing scale consisting of numerals printed on the display bezel will be provided. It will be possible to adjust the center of the display to be oriented either to true North or to own ship's heading.

The display is to be 9 inches wide and 7 inches high. It will use a P4 phosphor and is expected to provide a means for visual integration of target signals by the operator. This integration presumably may be enhanced with appropriate settings of the bias and gain controls. The operator is also presumed to be able to acquire enough experience to distinguish between own ship and target indications on the display. These presumptions are the source of some concern in view of available data from other systems on similar operator-display relationships.

The documents reviewed do not contain specific reasons for the choice of phosphor, nor is any justification given for the choice of display size. HFR has conducted experimental studies

both ashore and at sea to determine optimum settings for bias and gain on sonar displays and have typically found them to be quite different from those selected by operators (2). The possibility of reducing the gain to eliminate noise to such a low level that detections may be missed is recognized in the documents but unfortunately no further development of it is given.

The problem of "self-noise" in the BQQ-2 system has given strong impetus to a noise reduction program. This program is ongoing and will probably continue for some time. Investigations of classification problems in the BQQ-2 system indicate that it is unlikely the operator will ever be able to recognize all of the variable and unstable disturbances on the display which are own-ship generated. (It is this problem which is thwarting progress in classification techniques.)

The references to page location follow, with specific comments on each item:

Vol. I Page ref. I-2

Re: Display. "Further processing is provided by the operator's visual integration."

Comment. (a) What precisely is meant by visual integration?

(b) How critical is visual integration to system capability?

(c) Has it been measured either in the laboratory or at sea?

Vol. I Page ref. II-56

Re: Display/Operator Training. "Experience is expected to teach the operator which disturbances on the display are own ship generated."

Comment: (a) This may not be feasible since ownship and self-noise traces are highly variable.

(b) Does experience mean on-the-job training? If so, what assurance is there that systematic procedures will be initiated aboard each submarine to determine the pattern of these disturbances? What role, if any, should the schools play?

Vol. I Page ref. II-56

Re: Bias/Gain. "A hazard is present in that the operator now has what can be interpreted as a marking level control. It has been illustrated in other instances that operators set displays until they feel the appearance is pleasing but these may be far from the optimum for detection."

Comment: (a) Specific research aimed at defining a set of threshold values for this equipment to avoid the possibility of missed contacts caused by low-level setting would be profitable.

Vol. II Page ref. II-19

Re: "Display Study." "The display was presented on an ITT model 1770AD oscilloscope with P7 Phosphor."

Comment: (a) Subsequently, it was decided the display should have a P4 phosphor. Is there any experimental or other evidence which shows that the properties of a P4 phosphor are superior to those of a P7 phosphor for the DIMUS application?

Proposal Page ref. II-18

Re: Bright Tube. "A direct view cathode-ray tube shall be used as the final display media. It shall be a P4 phosphor aluminized screen tube operated so that a screen brightness of at least 60 foot lamberts is attainable."

Comment: (a) Why was a P4 phosphor selected?

(b) There are three kinds of P4 phosphor:

Phosphor	Fluor. Color	Persistence
P4 Sulphide	Green	Short
P4 Silicate	Blue-green	Medium
P4 Silicate-Sulphide	White	Medium

which one is proposed for use?

(c) What level of ambient illumination should be specified for the most efficient detection performance?

Proposal Page ref. II-19

Re: Usable Area. "The usable display shall be at least nine inches by seven inches in width and height respectively."

Comment: (a) How were the display dimensions determined? No experimental or other evidence is offered to support the proposed size.

3. RELIABILITY AND TESTING

The reliability and maintainability philosophies for the BQR-7 DIMUS system are based on three major concepts. These are discussed in the paragraphs following.

(1) The expected reliability is defined, within stated limits, as patterned after portions of the 412 L Air Weapons Control System. The contractor is attempting to reduce misapplication of electronic components and is concentrating on "critical item localization." A mean-time-to-repair (MTTR) of 30 minutes is specified.

From informal observations made by HFR staff in connection with other and similar aspects of the BQQ-2 system, this 30-minute MTTR seems optimistic. Perhaps some actual at-sea tests on operational nuclear submarines could give definitive data on the choice of a 30-minute MTTR.

(2) System reliability will purportedly be enhanced by the inclusion of automatic on-line fault localization plus a manual checking schedule.

Automatic fault detection should, of course, be compatible with the greater requirements of the BQQ-2 Central Maintenance System. References to this compatibility are few. The possibility that the automatic on-line testing system will fail or at least give false indications does not seem to have been considered. The manner by which the sonar technician locates and repairs faults in the DIMUS system is unclear.

(3) System reliability will be demonstrated in a test program prior to equipment delivery to the Navy. This program is based on the standard military specification covering equipment testing.

HFR suggests that the program may be excessive in those portions dealing with vibration testing, and lacking in consideration of problems that may arise from immediate environmental factors such as moisture, ease of access, deterioration, drying out of components. Since the contractors are working to a military specification, perhaps the specification itself was framed for other considerations. In the "proposal" volume under review the discussion of non-relevant failures uses the term "operator error" without precise definition. It would seem that if operator error were a predictable cause of failure, there must be a built-in or basic design fault that is the true cause of the failure.

In the detailed references which follow, specific and pertinent questions are raised concerning the subjects discussed above.

Vol. I Page ref. II-63

Re: Test Circuit Failures. "...where the operator's decision is better, include failures in the

testing circuits or failures in the processor which degrade performance below the predetermined acceptable level but are acceptable for the existing tactical situation."

Comment: (a) "The operator's decision is better"--than what?

(b) How are failures in the testing circuits found--particularly in automatic on-line testing?

(c) Perhaps the procedures defining manual testing of the test circuits should be outlined.

Vol. I Page. ref. III-23

Re: Testing. "Portions of the system not automatically tested will be manually tested at intervals deemed sufficient to attain the desired system availability."

Comment: (a) If the intervals referred to mean "at 12-hour intervals" (referred to in other sections), what is the criterion of "desired system availability?"

Vol. I Page ref. III-23

Re: Testing. "Each hydrophone channel will be manually checked every 12 hours."

Comment: (a) At what physical point in the system will the measurements of each channel be made?

(b) Does external test equipment have to be used or is it installed as part of the equipment?

Vol. II Page ref. I-2

Re: Reliability. "The equipment MTTR was originally specified at one hour and revised to take into account mission requirements to 1/2 an hour with a fifteen minute goal."

Comment: (a) From experience gained with the fleet, the figure of 30 minutes seems optimistic. Perhaps the evidence used to support this expectation should be cited.

Vol. II Page ref. I-53

Re: Testing. "It is assumed that manual checking is carried out on a twice-a-day basis, i.e., once every 12 hours. On an average basis, an undetected fault would exist for six hours."

Comment: (a) The evidence for the assumed 12-hour checks is not presented nor is the relationship of this test program to present fleet practice defined.

(b) Is a fault undetected for six hours an acceptable time?

Vol. II Page ref. I-99

Re: Reliability. "Analysis of available delay-line failure rate data taken from the 412 L Air Weapons Control System shows the following breakdown of failure causes out of 107 failures." (Table follows in text of Vol. II.)

Comment: (a) The extrapolation of failure rate data from a ground-based radar system to a ship-based sonar system is questionable.

(b) The instability, changes in values and intermittent operations causing failures in the sample constituted over 60 percent of the total. It seems reasonable to assume that the moisture, vibration, shock and difficulty of access aboard submarines may cause similar failures but at a considerably higher level.

Vol. II Page ref. I-101

Re: Reliability. "The evaluation of core memory failure rates is expected to continue and will include provisions for quality assurance to

increase the probability of achieving the lower failure rates in the final equipment."

Comment: (a) Unless this evaluation is specified in terms of time the contractor may claim the equipment is still in a developmental stage when, in fact, it should be at the operational acceptance level.

(b) What are the provisions referred to above for quality assurance?

Proposal Page ref. II-25

Re: Fault Location and Isolation. "When a fault is found by automatic testing, an indicating light shall be lit to indicate its location. .... Test points shall be located on plug-in cards to facilitate rapid location of faults to the card level."

Comment: (a) Where is the indicating light displayed? Will the watchstander be able to see it?

(b) To what level of fault does the indicating light pertain? i.e., cabinet, subassembly with cabinet?

(c) Are plug-in cards of a standard design used throughout the BQR-7 DIMUS system?

Proposal Page ref. II-28

Re: Application Information. "Probably the greatest cause of failure is misapplication of the component parts. Knowing that incorrect use can nullify any theoretical built-in reliability, certain rules of good engineering practice have been formulated and will be included in the AN/BQR-7 DIMUS Project Data Book."

Comment: (a) Does "misapplication" mean using the wrong parts in a certain circuit or module?

(b) Specifically, what rules of good engineering practice will prevent this happening?

Proposal Page ref. II-28

Re: Test Relationship. "Certain signals shall be made available to the central maintenance facility for monitoring purposes."

Comment: (a) What signals will be made available (in addition to power supply voltages, equalizer and hard limiter outputs and 500-kc clock signals)?

(b) From what points in the BQR-7 DIMUS system will they be taken?

Proposal Page ref. II-30

Re: Mean Time Between Failures. "A system failure is defined as that condition caused by catastrophic or drift degradation not correctable in normal preventative maintenance which causes the system to operate below minimum performance levels."

Comment: (a) How are minimum performance levels defined and justified?

(b) If drift is a gradual degradation, how is this condition indicated using manual or automatic check-out systems?

(c) What would be the circumstances that permitted drift to reach a point which would cause system failure?

Proposal Page ref. II-33

Re: Periodic Testing. "Periodic manual testing in addition to built-in test equipment shall be performed."

Comment: (a) Presumably, periodic refers to the twice-per-day testing in addition to automatic on-line testing.

(b) If so, who does the testing?

Proposal Page ref. II-33

Re. Demonstration Test Program. " ..total equipment vibration time will be 1/2 of the 4400 hour test time in accordance with Figure 1 requirements.
Test Level: 1) Vibration 2 G, 20-60 cps.
2) On-off power cycling.
3) Temperature-class 4-50°c without cycling."

Comment: (a) The total equipment vibration test time specified in the program is equivalent to 376 hours or 15 1/2 days. Perhaps this is excessive in view of the controlled on-board environment in which this equipment will operate. No specifications are given which show how the equipment is to be mounted.

(b) The on-off power cycling test would seem to indicate a hazard with which the equipment will probably not be faced.

Proposal Page ref. II-36

Re: Non-relevant Failures. "Accident of mishandling, operator error, installation ... period of time."

Comment: (a) In the previous paragraph it states "non-relevant failures will be discounted." Presumably these will not be chargeable to system reliability.

(b) Failures due to operator error should be considered relevant failures if such failures are encountered repeatedly in some particular phase of system operation.

Proposal Page ref. III-16

Re: On-line Fault Detection. "...the devices incorporated to detect malfunctions to the piece part level in the off-line repair facility cannot be neglected."

Comment: (a) Reference to off-line repair are confusing since it was stated earlier that repair would consist of replacing faulty modules.

(b) What off-line facilities do they have in mind?

Proposal Page ref. III-8

Re: Reliability and Maintainability. "The objectives of the reliability system analysis function will be met by performing the following tasks as detailed design information becomes available:
1) Perform a system functional analysis.
2) Update reliability and maintainability model.
3) Determine effects of deck resonancy and air contamination on AN/BQR-7 equipment."

Comment: (a) Should not the final reliability/maintainability model/plan be evolved from operational testing of the equipment at sea rather than from strictly design information?

(b) Since this equipment will be housed in air-conditioned temperature-controlled spaces, will air contamination really be a factor in its performance?

Proposal Page ref. III-20

Re: Critical Item Localization. "...will serve to pin-point critical areas of equipment reliability. For some items, the state-of-the-art limits what can be done."

Comment: (a) Specifically, what items do they consider limited?

(b) Unless the "state-of-the-art" is defined as that presently known by G.E. or in general--the opportunity for avoidance of later responsibility is extended.

(c) Are alternate modes or substitutes being evolved?

(d) Will such substitutes change the maintenance/reliability philosophy?

4. MAINTAINABILITY, REPAIRS AND SPARES

The maintainability considerations for the BQR-7 DIMUS system are closely related to the points discussed in the section on reliability. The most important consideration is the decision that maintenance and repair should rely on replacement of faulty elements. Reference is made in the text to having at least one spare of each assembly in each cabinet. But no definition of an "assembly" is provided.

Observations on operational conditions at sea suggest that this policy regarding spare parts may prove impractical because of the serious space limitations aboard submarines. If so, a significant change in the replacement concept may be necessary.

It is stated that an attempt will be made to minimize the types of spares carried. This should, of course, be done after a determination of any commonality between BQR-7 DIMUS and other components of the BQQ-2 system in an effort to minimize the size of necessary on-board inventories. No direct reference to this problem is made in the text.

The MTTR of 30 minutes referred to in the section on reliability is based on laboratory time studies and military specifications. This estimate is suspect because of the lack of correspondence between the artificially staged time studies and the crowded, unconventional and harassing environment on board nuclear-attack submarines.

Comments describing the availability of work bench areas, special handling equipment and maintenance aids seem odd in view of the policy that repair will consist of replacement.

Although preventive maintenance and repair of faults will presumably be done by shipboard personnel, the only reference to

manpower requirements is included under the title "maintainability estimates." Here, reference is made to the fact that "design consideration should be given to the logistics elements of spares, space location, assembly repair and manpower requirements." In view of the discussions in previous paragraphs, this seems too vague and ambiguous to be of positive value.

Specific references to the points raised in this section follow.

Vol. II Page ref. I-49

Re: Task Requirements. "The three prime fault determination levels are identified as automatic on-line monitor, manual off-line monitor, and scheduled preventative maintenance test."

Comment: (a) The difference between "manual off-line monitoring" and "scheduled preventative maintenance" is not made clear in the report.

Vol. II Page ref. I-51

Re: Spares. "Specific emphasis is placed on the concept of minimizing the number of types of spare assemblies required."

Comment: (a) In this concept of minimum types, has consideration been given to the interrelationship of assemblies with the rest of the BQQ-2 system?

(b) Are there standard assemblies or sub-units now available in the BQQ-2 system which would fit the design specifications of the BQR-7 DIMUS system?

Vol. II Page ref. I-49

Re: Spares. "Every effort will be made to provide at least one spare of each assembly within the cabinet requiring that assembly."

Comment: (a) Some definition of what is meant by an assembly should be made.

(b) In view of the badly cramped equipment spaces on board attack-class submarines--a one-to-one ratio of spare assemblies within cabinets seems impractical.

Vol. II Page ref. 1-54

Re: Repair Times. "Estimates of time to isolate faults ... probability of occurrence of a given task."

Comment: (a) The estimates of times to enter cabinets, locate faults, move to other compartments, etc., seem unduly optimistic in view of the times required to do these tasks in the crowded conditions aboard ship.

(b) The times given are admittedly estimates but to extrapolate to shipboard from time studies conducted in the laboratory would seem to have doubtful validity.

Proposal Page ref. II-32

Re: Mean Time to Repair. "The MTTR of equipment faults will be 0.5 hours or less mean value. ....Active repair time is defined as the period necessary for a qualified maintenance man to detect and to localize faults, to remove and replace failed assemblies and to check out the equipment to assure satisfactory operation."

Comment: (a) The estimation of time required for the detection and localization of faults in DIMUS is undoubtedly difficult. From our experience in the BQQ-2 and other shipborne systems the assumption that maintenance technicians will be as highly qualified as being able to perform tasks in the time indicated would seem to be highly optimistic.

(b) The rationale for a MTTR of 0.5 hours should be stated in detail.

Proposal Page ref. II-32

Re: Maintenance Concepts. "The equipment shall be designed to be repaired at sea by modular assembly replacement. Repair of assemblies shall not be accomplished as part of maintenance procedure."

Comment: (a) The "replace-not-repair" concept is practical only if sufficient spares can be carried.

(b) To what level is the modular replacement concept carried? i.e., what is the exact definition of a subassembly?

(c) Will there be sufficient storage space for spares on board?

Proposal Page ref. III-10

Re: Mean Time to Repair. "In predicting the MTTR, the times for performing various tasks will be estimated from data collected from such sources as laboratory time studies, ... military specifications."

Comment: (a) In the artificial and generally optimistic conditions which surround most laboratory time studies, inferences for "real-life" situations are of doubtful accuracy.

Proposal Page ref. III-11

Re: Reliability and Maintainability Allocation. "In the areas of new devices such as microelectronics where limited data is available, prediction techniques developed by General Electric will be utilized."

Comment: (a) What exactly are these "prediction techniques" that G.E. has developed and how would they be applied to the BQR-7 DIMUS program?

Proposal Page ref. III-11

Re: Maintainability Estimates. "While not an actual part of system equipment, design considerations must also be given to the logistics elements of maintainability, such as spares, space location, assembly repair, and manpower requirements."

Comment: (a) What criteria would be used in establishing manpower requirements?

(b) Would these manpower requirements include available skill levels, manning and times-on-watch? Will these be determined separately or as part of the other demands of the BQQ-2 system?

Proposal Page ref. III-14

Re: Maintainability Estimates. "Where it is feasible, time/motion studies will be initiated to generate replaceable assembly and printed-wire-board repair times."

Comment: (a) If the concept of replacement is followed, why is there an interest in time studies of printed-wire-board repair times?

Proposal Page ref. III-16

Re: Effects of Defective Units. "In the event that automatic fault detecting equipment is not capable of detecting a particular malfunction, additional maintenance aids will be recommended."

Comment: (a) A subsequent paragraph mentions test points, accessible locations, indicator lights and meters as examples of maintenance aids.

Rather than wait for an evaluation of the on-line monitoring equipment, perhaps certain maintenance features should be considered and incorporated in the design stage.

Proposal Page ref. III-17

Re: On-ship Tools and Test Equipment. "...information will be used to justify work bench areas, spare parts storage facilities, and special handling equipment if required ...."

Comment: (a) Special work bench areas solely for the AN/BQR-7 DIMUS would not be acceptable in view of the space available on board nuclear-attack submarines.

(b) Consolidation of such requirements should be made with the needs of the rest of the BQQ-2 system in mind.

(c) To what does special handling equipment refer?

5. HUMAN FACTORS -- GENERAL

Although a section in the source material is specifically entitled "Human Factors" it is almost entirely oriented to the changes in system maintainability that will be caused by the adoption of a CRT instead of a paper recorder. The proposal also refers to the preparation of human engineering principles for inclusion in the Project Data Book.

Though dissemination of human engineering principles is a desirable general goal, it seems of doubtful value to have them published in a Project Data Book. The advantages are not clear.

Missing from the human factors discussions for the BQR-7 DIMUS are factors which should constitute major considerations in a new equipment program. These are:

(1) delineation of special or novel skills that may be required to operate and/or maintain the equipment.

(2) functional analysis of control usage and placement on the operator console.

(3) discussion of the information transfer problems inherent in processing and displaying new information for detection of targets.

(4) discussion of the criteria used in the "trade-off considerations" discussed in Volume I, to justify the use of a 3-db threshold point in noting performance variation.

Education and training are discussed at some length but only in the context of indoctrination for G.E. employees and vendors in the areas of reliability and maintainability. Emphasis is placed in this program on good workmanship (and thereby presumably good reliability). No intention is evident that any operational or factory training of Navy personnel is involved

The references follow.

Vol. II Page ref. I-3

Re: Performance/Display. "...the performance degradation for minimum acceptable performance. Realistic trade-off considerations for an optimization of overall system effectiveness are an essential part of the study program. The 3 db point is considered as the point at which a good operator viewing a bright tube display can note a performance variation."

Comment: (a) What evidence is offered that operators can actually note a performance variation at the 3-db point?

(b) What is meant by "realistic trade-off considerations?"

(c) Some evidence--either experimental or empirical--should be cited to support the use of 3 db as a threshold figure from which to judge performance variation, particularly in measuring the performance of the system.

Proposal Page ref III-25

Re: Human Factors. ".... 2) Assure that man/machine relations have not been significantly changed in the conversion of the display to CRT type from Paper Recorder. 3) Prepare human engineering principles for Project Data Book."

Comment: (a) What about the relative quality/ quantity of information displayed?

(b) What criteria, if any, were used in assuring no change had taken place in man/ machine relationships?

(c) No experimental work on CRT vs. BTR is reported in the documentation received.

(d) The human engineering effort seems to be strongly oriented to analysis of the maintainability variations caused by the new display. Little effort seems to have been directed to the design of the console or the usefulness of the various controls.

(e) Reiteration of known human engineering principles, already well documented in standard texts seems a needless exercise. The benefits to be gained are not clear.

Proposal Page ref. III-63

Re: Education and Training. "...this reliability and maintainability indoctrination is not limited to Heavy Military Electronics Department employees. It includes everyone connected with the contract, i.e., subcontractors, contractor, supplier, etc."

Comment: (a) This program is an in-house effort to teach certain principles of good workmanship to contractor and subcontractor employees.

(b) It apparently is not meant to include USN personnel since the emphasis is on production-line reliability.

REFERENCES

1. Anderson, Victor C. BQR-2B DIMUS. University of California, La Jolla Marine Physical Laboratory of the Scripps Institution of Oceanography, San Diego 52, California.

2. Baker, C. H. Human factor problems in anti-submarine warfare, Technical Report 206-20. Improvement in sonar operator detection performance consequent to the use of optimum bias and gain. (For Personnel and Training Branch, Psychological Sciences Division, Office of Naval Research.) 1963, Contract Nonr 2649(00).

APPENDIX I

LIST OF REFERENCES
SEQUENTIALLY KEYED TO PAGE NUMBERS

VOLUME I

FINAL REPORT

AN/EQR-7 All-Digital Preformed Beam Receiver Study (U)

Dated 30 September 1965
Contract NObsr 91093, Items 1-2
Project Serial Number SF 001-03-06, Task 8239

General Electric Company
Heavy Military Electronics Department
Syracuse, New York

1. Page ref. I-2

   Re: Display. "Further processing is provided by the operator's visual integration."

   Comment: (a) What precisely is meant by visual integration?

   (b) How critical is visual integration to system capability?

   (c) Has it been measured either in the laboratory or at sea?

2. Page ref. II-56

   Re: Display/Operator Training. "Experience is expected to teach the operator which disturbances on the display are own-ship generated."

   Comment: (a) This may not be feasible since own-ship and self-noise traces are highly variable.

   (b) Does experience mean on-the-job training? If so, what assurance is there that systematic procedures will be initiated aboard each submarine to determine the pattern of these disturbances? What role, if any, should the schools play?

3. Page ref. II-56

   Re: Displays/Operation. "The operator must determine by clues, such as zero relative bearing rate, that these are not targets and adjust out these differences."

   Comment: (a) Other clues are not listed. Can they be anticipated? Are all signals with zero relative bearing rates to be considered as noise?

4. Page ref. II-56

   Re: Displays/Operation. "If variables change rather frequently, e.g., hourly, the operator must exert much effort in keeping the spoke repressor adjusted."

   Comment: (a) What is meant by "much effort"?

5. Page ref. II-56

Re: Bias/Gain. "A hazard is present in that the operator now has what can be interpreted as a marking level control. It has been illustrated in other instances that operators set displays until they feel the appearance is pleasing but these may be far from the optimum for detection."

Comment: (a) Specific research aimed at defining a set of threshold values for this equipment to avoid the possibility of missed contacts caused by low-level settings would be profitable.

6. Page ref. II-57

Re: Operator/Workload. "The operator is not overloaded with work but is now left with the capability of eliminating target traces along with the interference. Experience will be required to learn under what circumstances it is desirable to select a [illegible] repressor output.

Comment: (a) The validity of this assertion concerning the operator's (task) workload and his capability of eliminating target traces is not obvious.

(b) How is this experience gained? Does it refer to operator experience solely obtained at sea using live targets and extracting operational information? Or does the statement refer to familiarity with the equipment such as would be gained at a school?

7. Page ref. II-58

Re: Display Time. 1.) "Time averager outputs up to half to one hour old must be recalled for display." 2.) "A purely subjective feeling that at least a half-hour history (preferably up to one hour) should be displayed."

Comment: (a) It is never expressly stated exactly why this time period was selected beyond providing additional history to help in maintaining contact on questionable targets. Probably some relationship to information requirements should be established.

8. Page ref. II-63

Re: Test Circuit Failures. "...where the operator's decision is better, include failures in the testing circuits or failures in the processor which degrade performance below the predetermined acceptable level but are acceptable for the existing tactical situation."

Comment: (a) The operator's decision is better--than what?

(b) How are failures in the testing circuits found--particularly in automatic on-line testing?

(c) Perhaps the procedures defining manual testing of the test circuits should be outlined.

9. Page ref. III-23

Re: Testing. "Portions of the system not automatically tested will be manually tested at intervals deemed sufficient to attain the desired system availability."

Comment: (a) If the intervals referred to mean "at 12 hour intervals" (referred to in other sections), what is the criterion of "desired system availability?"

10. Page ref. III-23

Re: Testing. "Each hydrophone channel will be manually checked every 12 hours."

Comment: (a) At what physical point in the system will the measurements of each channel be made?

(b) Does external test equipment have to be used or is it installed as part of the equipment?

APPENDIX II

LIST OF REFERENCES
SEQUENTIALLY KEYED TO PAGE NUMBERS

VOLUME II

FINAL REPORT

AN/BQR-7 All-Digital Preformed Beam Receiver Study (U)

Dated 30 September 1965
Contract NObsr 91093, Items 1-2
Project Serial Number SF 001-03-06, Task 8239

General Electric Company
Heavy Military Electronics Department
Syracuse, New York

1. Page ref. I-2

   Re: Reliability. "The equipment MTTR was originally specified at one hour and revised to take into account mission requirements to 1/2 an hour with a fifteen minute goal."

   Comment: (a) From experience gained with the fleet the figure of 30 minutes seems optimistic. Perhaps the evidence used to support this expectation should be cited.

2. Page ref. I-3

   Re: Performance/Display. "The performance degradation for minimum acceptable performance should be 3 db below normal performance. Realistic trade-off considerations for an optimization of overall system effectiveness are an essential part of the study program. The 3 db point is considered as the point at which a good operator viewing a bright tube display can note a performance variation."

   Comment: (a) What evidence is offered that operators can actually note a performance variation at the 3-db point?

   (b) What is meant by "realistic trade-off considerations"?

   (c) Some evidence--either experimental or empirical--should be cited to support the use of 3 db as a threshold figure from which to judge performance variation, particularly in measuring the performance of the system.

3. Page ref. I-49

   Re: Spares. "Every effort will be made to provide at least one spare of each assembly within the cabinet requiring that assembly."

   Comment: (a) Some definition of what is meant by an assembly should be made.

   (b) In view of the badly cramped equipment spaces on board attack-class submarines--a one-to-one

ratio of spare assemblies within cabinets seems impracticable.

4. Page ref. I-49

Re: Task Requirements. "The three prime fault determination levels are identified as automatic on-line monitor, manual off-line monitor, and scheduled preventative maintenance test."

Comment: (a) The difference between "manual off-line monitoring" and "scheduled preventative maintenance" is not clear in the report.

5. Page ref. I-51

Re: Spares. "Specific emphasis is placed on the concept of minimizing the number of types of spare assemblies required."

Comment: (a) In this concept of minimum types, has consideration been given to the inter-relationship of assemblies with the rest of the BQQ-2 system?

(b) Are there standard assemblies or sub-units now available in the BQQ-2 system which would fit the design specifications of the BQR-7 DIMUS system?

6. Page ref. I-53

Re: Testing. "It is assumed that manual checking is carried out on a twice-a-day basis, i.e., once every 12 hours. On an average basis, an undetected fault would exist for six hours."

Comment: (a) The evidence for the assumed 12 hour checks is not presented nor is the relationship of this test program to present fleet practice defined.

(b) Is a fault undetected for six hours an unacceptable time?

7. Page ref. I-54

Re: Repair Times. "Estimates of time to isolate faults ... probability of occurrence of a given task."

Comment: (a) The estimates of times to enter cabinets, locate faults, move to other compartments, etc., seem unduly optimistic in view of the time required to do these tasks in the crowded conditions on board ship.

(b) The times given are admittedly estimates but to extrapolate to shipboard from time studies conducted in the laboratory would seem to have doubtful validity.

8. Page ref. I-99

Re: Reliability. "Analysis of available delay line failure rate data taken from the 412 L Air Weapons Control System shows the following breakdown of failure causes out of 107 failures." (Table follows in text.)

Comment: (a) The extrapolation of failure rate data from a ground-based radar system to a ship-based sonar system is questionable.

(b) The instability, changes in values and intermittent operations causing failures in the sample constitute over 60 per cent of the total. It seems reasonable to assume that the moisture, vibration, shock and difficulty of access aboard submarines may cause similar failures but at a considerably higher level.

9. Page ref. I-101

Re: Reliability. "The evaluation of core memory failure rates is expected to continue and will include provisions for quality assurance to increase the probability of achieving the lower failure rates in the final equipment."

Comment: (a) Unless this evaluation is specified in terms of time, the contractor may claim the equipment is still in a developmental stage when, in fact, it should be at the operational acceptance level.

(b) What are the provisions referred to above for quality assurance?

10. Page ref. II-19

Re: "Display Study." "The display was presented on an ITT model 1770AD oscilloscope with P7 Phosphor."

Comment: (a) Subsequently, it was decided the display should have a P4 phosphor. Is there any experimental or other evidence which shows that the properties of a P4 phosphor are superior to those of a P7 phosphor for the DIMUS application?

APPENDIX III

LIST OF REFERENCES
SEQUENTIALLY KEYED TO PAGE NUMBERS

PROGRAM PLAN FOR PHASE II
AN/BQR-7 DIMUS

PROPOSAL 371-006
September 1965

General Electric Company
Heavy Military Electronics Department
Syracuse, New York

1. Page ref. II-15

Re. Long Time Averager. "...cycle length is selectable by the operator."

Comment: (a) What are to be the operator's criteria governing selection?

(b) What are the results if the wrong selection is made?

2. Page ref. II-17

Re: Manual Mode. "Integer numbers in the range ± 1023, quantized in steps of eight, shall be capable of being inserted by the operator, one beam at a time."

Comment: (a) There are 62 beams. How does the operator insert the relative integer numbers into the memory?

(b) What are the variables which govern insertion?

3. Page ref. II-17

Re: Automatic Mode. "An operator control shall allow replacement of the value being used for spoke repression by the 'latest available value.'"

Comment: (a) What is the "latest available" value?

(b) How is such a value made known to the operator?

(c) What happens if the value in use is not replaced by the "latest available" value?

4. Page ref. II-18

Re: Bright Tube. "A direct viewed cathode-ray tube shall be used as the final display media. It shall be a P4 phosphor aluminized screen tube operated so that a screen brightness of at least 60 foot lamberts is attainable.

Comment: (a) Why was a P4 phosphor selected?

(b) There are three kinds of P4 phosphor:

Phosphor	Fluor. Color	Persistence
P4 Sulphide	Green	Short
P4 Silicate	Blue-green	Medium
P4 Silicate-Sulphide	White	Medium

which one is proposed for use?

(c) What level of ambient illumination should be specified for the most efficient detection performance?

5. Page ref. II-19

Re: Usable Area. "The usable display shall be at least nine inches by seven inches in width and height respectively."

Comment: (a) How were the display dimensions determined? No experimental or other evidence is offered to support the proposed size.

6. Page ref. II-25

Re: Fault Location and Isolation. "When a fault is found by the automatic testing, an indicating light shall be lit to indicate its location. .... Test points shall be located on plug-in cards to facilitate rapid location of faults to the card level."

Comment: (a) Where is the indicating light displayed?

(b) To what level of fault does the indicating light pertain? i.e., cabinet, subassembly with cabinet?

(c) Are plug-in cards of a standard design used throughout the BQR-7 DIMUS system?

7. Page ref. II-28

Re: Application Information. "Probably the greatest cause of failure is misapplication of the component parts. Knowing that incorrect use can nullify any theoretical built-in reliability, certain rules of good engineering practice have been formulated and will be included in the AN/BQR-7 DIMUS Project Data Book."

Comment: (a) Does "misapplication" mean using the wrong parts in a certain circuit and module?

(b) Specifically, what rules of good engineering practice will prevent this happening?

8. Page ref. II-28

Re: Test Relationship. "Certain signals shall be made available to the central maintenance facility for monitoring purposes."

Comment: (a) What signals will be made available (in addition to power supply voltages, equalizer and hard limiter outputs and 500-kc clock signals)?

(b) From what points in the BQR-7 DIMUS system will they be taken?

9. Page ref. II-30

Re: Mean Time Between Failures. "A system failure is defined as that condition caused by catastrophic or drift degradation not correctable in normal preventative maintenance which causes the system to operate below minimum performance levels."

Comment: (a) How are minimum performance levels defined and justified?

(b) If drift is a gradual degradation how is this condition indicated using manual or automatic check-out systems?

(c) What would be the circumstances that permitted drift to reach a point which would cause system failure?

10. Page ref. II-32

Re: Mean Time to Repair. "The MTTR of equipment faults will be 0.5 hours or less mean value. .... Active repair time is defined as the period necessary for a qualified maintenance man to detect and to localize faults, to remove and replace failed assemblies and to check out the equipment to assure satisfactory operation."

Comment: (a) The estimation of time required for the detection and localization of faults in DIMUS is undoubtedly difficult. From our experience in the BQQ-2 and other shipborne systems the assumption that maintenance technicians will be as highly qualified as being able to perform tasks in the time indicated, would seem to be highly optimistic.

(b) The rationale for the MTTR of 0.5 hours should be stated in detail.

11. Page ref. II-32

Re. Maintenance Concepts. "The equipment shall be designed to be repaired at sea by modular assembly replacement. Repair of assemblies shall not be accomplished as part of maintenance procedure."

Comment. (a) The "replace-not-repair" concept is practical only if sufficient spares can be carried.

(b) To what level is the modular replacement concept carried? i.e., what is the exact definition of a subassembly?

(c) Will there be sufficient storage space for spares on board?

12. Page ref. II-33

Re: Periodic Testing. "Periodic manual testing in addition to built-in test equipment shall be performed."

Comment: (a) Presumably, periodic refers to the twice-per-day testing in addition to automatic on-line testing.

(b) If so, who does the testing?

13. Page ref. II-33

Re: Demonstration Test Program. "...total equipment vibration time will be 1/12 of the 4400 hour test time in accordance with Figure 1 requirements.

Test level: 1) Vibration 2 G, 20-60 cps.
2) On-off power cycling.
3) Temperature-class 4-50°c without cycling."

Comment: (a) The total equipment vibration test time specified in the program is equivalent to 376 hours or 15 1/2 days. Perhaps this is excessive in view of the controlled on-board environment in which this equipment will operate. No specifications are given which show how the equipment is to be mounted.

(b) The on-off power cycling test would seem to indicate a hazard with which this equipment will probably not be faced.

14. Page ref. II-35

Re: Maintainability Demonstration. "A maintainability demonstration plan to show the reasonableness of equipment repair within 0.5 hours on an average basis will be prepared."

Comment: (a) Should such a plan entail a sampling of typical jobs in actual or realistically simulated surroundings?

(b) What would the selection criteria for the sample tasks be?

(c) Has such a plan actually been prepared? If not, when will it be ready?

15. Page ref. II-36

Re: Non-relevant Failures. "Accident of mishandling, operator error, installation ... period of time."

Comment: (a) In the previous paragraph it states "non-relevant failures will be discounted"--presumably these will not be chargeable to system reliability.

(b) Failures due to operator error should be considered relevant failures if such failures are encountered repeatedly in some particular phase of system operation.

16. Page ref. III-8

Re: Reliability and Maintainability. 1.) "The objectives of the reliability and maintainability system analysis function will be met by performing the following tasks as detailed design information becomes available--perform a system functional analysis. 2.) Update reliability and maintainability model. 3.) Determine effects of deck resonancy and air contamination on AN/BQR-7 equipment."

Comment: (a) Should not the final reliability/maintainability model/plan be evolved from operational testing of the equipment at sea rather than from strictly design information?

(b) Since this equipment will be housed in air-conditioned temperature-controlled spaces will air contamination really be a factor in its performance?

17. Page ref. III-10

Re: Mean Time to Repair. "In predicting the MTTR, the times for performing various tasks will be estimated from data collected from such sources as laboratory time studies, ... military specifications."

Comment: (a) In the artificial and generally optimistic conditions which surround most laboratory time studies, inferences for "real-life" situations are of doubtful accuracy.

18. Page ref. III-11

Re: Reliability and Maintainability Allocation. "In the areas of new devices such as microelectronics where limited data is available, prediction techniques developed by General Electric will be utilized."

Comment: (a) What exactly are these "prediction techniques" that G.E. has developed and how would they be applied to the BQR-7 DIMUS program?

19. Page ref. III-11

Re: Maintainability Estimates. "While not an actual part of system equipment, design considerations must also be given to the logistics elements of maintainability, such as spares, space location, assembly repair, and manpower requirements."

Comment: (a) What criteria would be used in establishing manpower requirements?

(b) Would these manpower requirements include available skill levels, and times-on-watch? Will these be determined separately or as part of the other demands of the BQQ-2 system?

20. Page ref. III-14

Re: Maintainability Estimates. "Where it is feasible, time/motion studies will be initiated to generate replaceable assembly and printed-wire-board repair times."

Comment: (a) If the concept of replacement is followed why is there an interest in time studies of printed-wire-board repair times?

21. Page ref. III-16

Re: Effects of Defective Units. "In the event that automatic fault detecting equipment is not capable of detecting a particular malfunction additional maintenance aids will be recommended."

Comment: (a) A subsequent paragraph mentions test points, accessible locations, indicator lights and meters as examples of maintenance aids.

Rather than wait for an evaluation of the on-line monitoring equipment, perhaps certain maintenance features should be considered and incorporated in the design stage.

22 Page ref III-16

Re: On-line Fault Detection. "...the devices incorporated to detect malfunctions to the piece part level in the off-line repair facility cannot be neglected."

Comment: (a) References to off-line repair are confusing since it was stated earlier that repair would consist of replacing faulty modules.

(b) What off-line facilities do they have in mind?

23. Page ref. III-17

Re: On-ship Tools and Test Equipment. "...information will be used to justify work bench areas, spare parts storage facilities, and special handling equipment if required ...."

Comment: (a) Special work bench areas solely for the AN/BQR-7 DIMUS would not be acceptable in view of the space available on board nuclear-attack submarines.

(b) Consolidation of such requirements should be made with the needs of the rest of the BQQ-2 system in mind

(c) To what does special handling equipment refer?

24. Page ref. III-20

Re: Critical Item Localization. ". .will serve to pinpoint critical areas of equipment reliability. For some items, the state-of-the-art limits what can be done."

Comment: (a) Specifically, what items do they consider limited?

(b) Unless the "state-of-the-art" is defined as that presently known by G.E., or in general--the opportunity for avoidance of later responsibility is extended.

(c) Are alternate modes or substitutes being evolved?

(d) Will such substitutes change the maintenance/ reliability philosophy?

25. Page ref. III-25

Re. Human Factors. ".... 2) Assure that man/machine relations have not been significantly changed in the conversion of the display to CRT type from Paper Recorder. 3) Prepare human engineering principles for Project Data Book "

Comment: (a) What about the relative quality/quantity of information displayed?

(b) What criteria, if any, were used in assuring no change had taken place in man/machine relationships?

(c) No experimental work on CRT vs. BTR is reported in the documentation received.

(d) The human engineering effort seems to be strongly oriented to analysis of the maintainability variations caused by the new display. Little effort seems to have been directed to the design of the console or the usefulness of the various controls.

(e) Reiteration of known human engineering principles already well documented in standard texts seems a needless exercise. The benefits to be gained are not clear.

26. Page ref. III-63

Re: Education and Training. "...this reliability and maintainability indoctrination is not limited to Heavy Military Electronics Department employees. It includes everyone connected with the contract, i.e., subcontractor, contractor, supplier, etc."

Comment: (a) This program is an in-house effort to teach certain principles of good workmanship to contractor and subcontractor employees.

(b) It apparently is not meant to include USN personnel since the emphasis is on production-line reliability.